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MAP INTERPRETATION AND TERRAIN ANALYSIS COURSE (MITAC) FOR INFANTRYMEN: ILLUSTRATED LECTURES

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MAP INTERPRETATION AND TERRAIN ANALYSIS COURSE (MITAC) FOR INFANTRYMEN: ILLUSTRATED LECTURES

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FOREWORD

This research and development was performed through contract N00123-79-C-0319 with Anacapa Sciences, Inc. under exploratory development task area CF63.521.080 (USMC Personnel and Training Technology). It was sponsored by Headquarters Marine Corps (Code TDG-40).

This report is the second in a series relating to the development of land navigation training capabilities. The first (NPRDC Spec. Rep. 80-17) identified the map interpretation and land navigation tasks that infantrymen must perform and recommended ways of providing the training needed to develop skills to perform those tasks. The current report describes the objectives, assumptions, and factors that had an important influence on the training materials developed in response to those recommendations. The materials are currently being revised and evaluated using subject matter experts. A subsequent report will document their final development and evaluation.

The contributions and support provided by MAJ Howard Langdon, Project Officer, Headquarters, U.S. Marine Corps, are greatfully acknowledged.

The contracting officer's technical representative was Orvin A. Larson.

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SUMMARY

Problem

The U.S. Army and Marine Corps use maps and photo-imagery products to operate over a wide range of terrains. Personnel must be prepared to use these products not only for orientation and navigation but also to make tactical decisions quickly and accurately based on terrain considerations.

Objective

The objective of this research task was to develop experimental land navigation training materials for use in a prototype training course for Army and Marine infantrymen.

Approach

Map interpretation and terrain analysis course (MITAC) techniques were used to develop an illustrated tape-slide lecture on land navigation methods. MITAC techniques combine cartographic principles and practices with terrain association methods for training purposes.

Results

A five-part lecture series was developed based on the 1:50,000-scale topographic maps produced by the Defense Mapping Agency. The series includes lectures on (1) an introduction to map interpretation, (2) interpretation of terrain relief, (3) interpretation of inland hydrography, (4) interpretation of vegetation, and (5) interpretation of transportation lines.

Work in Progress

The experimental materials are currently being validated for task content and media compatibility using USMC subject matter experts (SMEs). They will be revised and organized per SME recommendations and tested for training effectiveness with participants from Marine infantry battalions.

CONTENTS

INTRODUCTION

Problem

The Army and Marine Corps use maps and photo-imagery products to operate over a wide range of terrains. Personnel must be prepared to use these products not only for orientation and navigation but also to make tactical decisions quickly and accurately based on terrain considerations. Training in map interpretation and terrain analysis is essential to ensure the highest capability in land navigation.

Objective

The objective of this project was to develop a prototype illustrated lecture course in map interpretation and terrain analysis that would augment and enrich the training that Army and Marine Corps infantrymen now receive in land navigation and tactical planning. The training materials developed under this project are not intended to replace any existing training. Rather, they are intended to supplement that training by (1) providing more comprehensive training in map interpretation and (2) exposing infantrymen trainees to map interpretation problems encountered in a wider range of topography than presently possible.

Background

In 1975, the Army Research Institute (ARI) sponsored a project to design and develop a map interpretation and terrain analysis course (MITAC) to improve the ability of Army helicopter pilots to navigate accurately when flying at nap-of-the-earth (NOE) altitudes (McGrath, 1975; McGrath & Foster, 1975). MITAC was designed to supplement conventional training by increasing the knowledge of aviators on the many rules and conventions that cartographers follow when constructing maps. The instruction included the basis for the selection and classification of roads, coding criteria for vegetation cover, ground rules for delineating relief and drainage, the conventions used for grouping cultural features under standard symbols, the generalization and displacement practices in cartographic drafting, and many other design practices that must be understood if maps are to be interpreted accurately. To supplement the map theory, MITAC provided practical training through cinematic simulation exercises. MITAC has been well received by the aviation community and is now being used to train both Army and Marine Corps helicopter pilots.

Representatives of the Army infantry reviewed MITAC and indicated that it had potential for training infantrymen. Consequently, ARI sponsored a study to assess the extent to which the MITAC technology developed for aviator training could be applied to infantryman training. This was done through (1) on-site interviews with military personnel engaged in training infantrymen in land navigation and map interpretation, (2) interviews with cartographers, and (3) a review of current training methods and materials. The study concluded that MITAC had potential for infantry training but that textual materials and cinematic simulation exercises must be specifically tailored to the infantryman's knowledge and skills, as well as to the specific capabilities and aptitudes of the training target groups. It was recommended that a detailed study of infantrymen's knowledge and skill requirements be conducted before attempting to develop a prototype MITAC for infantrymen (Cross & McGrath, 1976).

In 1978, the Marine Corps sponsored a research effort designed to (1) identify the map interpretation and land navigation tasks that an infantryman must perform, (2) define the skills and knowledge required to perform those tasks, and (3) recommend means of providing the training needed to develop those skills (Cross & Rogers, 1980). The current

study was undertaken to develop prototype training materials that fulfill, in part, the recommendations made in the Cross and Rogers (1980) research.

APPROACH

Training Target Group

The training materials developed under this project were tailored to the knowledge and skills requirements of platoon leaders and platoon sergeants. These requirements are described in detail by Cross & Rogers (1980). The training of platoon sergeants is critical because they must be prepared to assume command of the platoon if the platoon leader becomes a casualty. The training of platoon leaders is critical because the platoon must be capable of operating independently on a routine basis. Thus, platoon leaders must be capable of performing all map interpretation tasks associated with the planning and execution of infantry operations.

Although platoon sergeants and leaders are the primary training target groups, it is assumed that the training materials developed for them could be simplified and used for training lower-ranking personnel (e.g., squad leaders) or expanded and used for training higher-ranking personnel (e.g., company commanders and battalion commanders).

Defense Mapping Agency Maps

The training materials were designed to enhance an infantryman's ability to interpret the standard 1:50,000-scale topographic maps produced by the Defense Mapping Agency (DMA). Foreign-made maps were mentioned only when the differences in the design of DMA and foreign maps were such that strong negative training transfer seemed probable.

Range of Topography

Since map-interpretation problems vary with topographic characteristics of an area, a training program in map interpretation must cover a wide variety of terrain types. Thus, every attempt was made to develop training materials that would cover the full range of topography found in the continental U.S. Consequently, the training materials employ 35-mm color slides of topographic features in Alabama, Arizona, California, Florida, Idaho, Kansas, Kentucky, Montana, North Carolina, Texas, and Washington.

Range of Seasons

The training materials were primarily aimed at navigation and tactical planning during the summer months when the trees and other vegetation are in full foliage. However, some attention was given to the unique problems encountered during the winter months when trees may be bare and the ground covered with snow.

Basic Assumptions

Four assumptions had an important influence on the design and information content of the training materials. These assumptions are discussed below.

Prerequisite Knowledge and Skills

The first assumption was that all students who receive MITAC training have a working knowledge of the mechanics of map and compass use (i.e., knowledge and skills obtained through existing programs). Appendix A provides a detailed listing of the topics

covered in existing training and therefore defines the prerequisite knowledge and skills for MITAC training. The most critical prerequisite knowledge and skills include:

1. Knowledge of marginal information.
2. Ability to locate objects on a map using grid coordinate system.
3. Understanding of scale concept.
4. Ability to measure distance on a map and convert to ground distance.
5. Ability to estimate distance by pacing.
6. Knowledge of time-distance-rate formulas.
7. Understanding of true, magnetic, and grid direction.
8. Understanding of azimuth and back azimuth.
9. Ability to use declination diagram to convert from magnetic to grid, and vice versa.
10. Ability to use the techniques of intersection and resection in locating an unknown point on map or ground.

Since many platoon sergeants and leaders do not have a working knowledge of the mechanics of map and compass use, individuals should be tested and, if necessary, given refresher training prior to MITAC training.

Actual Maps and Terrain

The second assumption was that effective training materials must expose students to actual maps and terrain. The training materials presently used to teach infantrymen to interpret terrain relief make heavy use of artists' renditions of terrain relief and artists' renditions of the contour-line portrayal of terrain relief. While simple, idealized drawings are useful, they do not fully prepare the trainee to deal with the complexity of actual maps and terrain. Therefore, a large part of training in map interpretation must deal with actual maps and terrain (or photographs of terrain) in full complexity.

Range of Topography

The rules that cartographers follow when compiling a map vary as a function of the characteristics of the topography in the area being mapped. A map user cannot become truly proficient at map interpretation without a clear understanding of the manner in which the map compilation rules and practices vary from one geographical area to another. Thus, the third assumption was that effective training in map interpretation must cover a wide range of topography.

Unit Training

The fourth assumption was that further training in map interpretation and terrain analysis will be conducted within the unit. It is possible but not probable that MITAC training will be administered at a formal school (officer basic or NCO leadership school). Therefore, it seems prudent to make the worst-case assumption that the training will be administered in the unit by unit personnel who are not necessarily expert instructors and not necessarily highly knowledgeable about the subject being taught. The assumption that the training will be conducted by unit personnel has implications for both training media and training equipment. Specifically, the training material must be self-contained to the point that highly trained instructor personnel are not required, and the training material must not impose a requirement for complex or expensive training equipment.

Specific Training Objectives

The specific objectives of MITAC training are (1) to instruct students on the factors that influence map design, and (2) to teach students to interpret terrain relief and the other natural and man-made features portrayed on the map. These objectives are discussed below.

Factors Influencing Map Design

The purpose of MITAC is not to teach students how to design maps but, rather, to provide them with information on map-design rules and practices that are necessary for accurate interpretation of maps. The most important map-design topics are:

1. Map scale--The relationship between map scale and the type and amount of information that can be portrayed.

2. Feature selection--The selection criteria used by cartographers in selecting features for portrayal on the map.

3. Feature classification--The criteria used by cartographers in classifying topographic features into classes and types.

4. Generalization--The rules that govern the generalization of the shape of topographic features that are too small to be portrayed to scale.

5. Feature exaggeration--The rules cartographers follow in exaggerating the map size of topographic features that are too small to be portrayed to scale.

6. Displacement--The rules that cartographers follow in displacing symbols that would overlap if they were placed at their true location on the map.

Interpretation of Terrain Relief and Other Topographic Features

Is is necessary to develop in each student a high level of expertise in interpreting the contour-line depiction of terrain relief. Students must be capable of performing three different types of tasks: (1) terrain association, (2) lay-of-the-land conception, and (3) terrain masking assessment. Terrain association refers to associating landforms actually visible with their portrayal on the map. Lay-of-the-land conception refers to developing, through map study, an integrated concept of the general types of landforms, the specific size and shape of landforms, and the relative location of landforms in the geographical area of interest. Terrain masking is assessed by using a map to determine whether intervening terrain masks an observer's view of one or more distant points.

Also, students must be taught to interpret the portrayal of topographic features other than terrain relief, including hydrographic features, vegetation, and the various classes of man-made features portrayed on the map. Students must learn far more than the type of symbols used to portray the various classes of features. For each class of feature, students must learn (1) the rules and practices that influence the selection and classification of features and (2) how to judge the extent to which the map portrayal of features is generalized and displaced.

RESULTS

The training materials developed consist of a five-part lecture series, including 35-mm color slides and tape cassettes. The images are projected by dual projectors and appear on juxtaposed screens. The recorded commentaries are synchronized with audio signals that cause the projector to change slides. The topics addressed by the lectures and the number of slides and commentary units in each are shown in Table 1. A commentary unit addresses a single slide, or pair of slides, appearing on the screen at one time. Each slide represents a photograph of an actual topographic feature located in continental United States, a map segment, or a word group that defines a term or provides information on lecture organization and structure. The parts of the lecture series are described in the following paragraphs.

Table 1

MITAC Illustrated Lectures

Topic	Commentary Units	Slides
General Introduction	84	116
Interpretation of Terrain Relief	328	579
1. Encodement of terrain relief	129	228
2. Elevation and slope estimation	95	166
3. Basic landforms	48	83
4. Conceptualizing the lay-of-the-land	12	24
5. Assessing terrain masking	27	47
6. Terrain association	17	31
Interpretation of Inland Hydrography	427	699
1. Introduction	42	69
2. Streams	126	197
3. Lakes and ponds	143	250
4. Other hydrographic features	116	183
Interpretation of Vegetation	140	218
Interpretation of Transportation Lines	143	521
1. Principles of road interpretation	77	117
2. Roads	113	190
3. Railroads, bridges, cuts, and fills	123	214

General Introduction

The first part describes the objectives of the lecture series, identifies prerequisite knowledge and skills, provides an overview of the discussion topics, describes the type and function of DMA maps, and defines a number of key concepts and terms. It includes 84 commentary units and 116 slides.

Interpretation of Terrain Relief

The second part includes six lectures on the interpretation of terrain relief:

1. Encodement of Terrain Relief. This lecture, which includes 129 commentary units and 228 slides, covers the encodement of terrain-relief information on the map. Although it emphasizes the contour-line portrayal of terrain relief, it also discusses spot elevations, benchmarks, hatchures, area symbols (sand, gravel, lava, etc.), and special symbols (cliffs, levees, etc.).

2. Elevation and Slope Estimation. This lecture, which includes 95 commentary units and 166 slides, provides instruction on using topographic maps to estimate the elevation and slope of specific ground locations and describes the accuracy with which elevation and slope can be estimated from a map.

3. Basic Landforms. This lecture, which includes 48 commentary units and 83 slides, defines a set of basic landforms (i.e., hills, ridges, saddles, spurs, draws, valleys, flat-topped landforms, alluvial fans, and depressions in Karst topgraphy) and illustrates the contour-line portrayal of the landforms.

4. Conceptualizing the Lay-of-the-Land. This lecture, which includes 12 commentary units and 24 slides, describes methods for systematically enhancing the terrain-relief portrayal on maps, thereby making the lay-of-the-land more apparent.

5. Assessing Terrain Masking. This lecture, which includes 27 commentary units and 47 slides, defines and illustrates critical terms (e.g., intervisibility, mask, defilade, topographic crest, and military crest) and describes methods for developing terrain profiles and map overlays.

6. Terrain Association. This lecture, which includes 17 commentary units and 31 slides, provides instruction on techniques for associating real-world landforms with their map portrayal. After a detailed discussion of the terrain-association process, students are presented with five terrain-association problems. For each problem, a real-world scene is projected on one screen; and a photograph of a map segment, on the other. Students have 5 minutes to identify the location on the map at which the photograph was taken. At the end of the 5-minute period, a commentary unit gives the correct answer and describes the features that were keys to problem solution.

Interpretation of Inland Hydrography

The third part includes four lectures on the interpretation of inland hydrography:

1. Introduction. This lecture, which includes 42 commentary units and 69 slides, defines the term hydrography and describes and illustrates the coding parameters used to portray hydrographic features on the map.

2. Streams. This lecture, which includes 126 commentary units and 197 slides, discusses streams.

3. Lakes and Ponds. This lecture, which includes 143 commentary units and 250 slides, discusses lakes and ponds.

4. Other Hydrographic Features. This lecture, which includes 116 commentary units and 183 slides, discusses other natural and man-made hydrographic features,

including springs, wells, and cisterns; swamps, marshes, and bogs; sink holes; water conduits; canals and ditches. Each feature discussion covers:

a. Topic definition.
b. Performance objectives.
c. Critical terms.
d. Selection practices.
e. Classification practices.
f. Symbolization practices.
g. Generalization, exaggeration, and displacement practices (when relevant).
h. Use of feature class in operations planning.
i. Use of feature class as navigation checkpoints.

Interpretation of Vegetation

The fourth part comprises a lecture on interpretation of vegetation, which includes 140 commentary units and 218 slides. This lecture was designed to enhance the infantryman's ability to perform two tasks:

1. Determine if vegetation portrayed on the map is likely to provide concealment or to constitute an obstacle to movement.

2. Associate real-world vegetation patterns with their portrayal on the map and, from that association, use the vegetation patterns as navigation checkpoints.

Instruction in the performance of these tasks was provided for a variety of different types of typography, ranging from arid deserts to humid, heavily forested areas.

Interpretation of Transportation Lines

The fifth part includes three lectures on the interpretation of transportation lines.

1. Principles of Road Interpretation. This lecture, which includes 77 commentary units and 117 slides, discusses general principles of road interpretation that apply to all large-scale topographic maps.

2. Roads. This lecture, which includes 113 commentary units and 190 slides, focuses on the problems and pitfalls encountered when interpreting the roads portrayed on DMA maps of U.S. areas.

3. Railroads, Bridges, Cuts, and Fills. This lecture, which includes 123 commentary units and 214 slides, discusses the interpretation of railroads, bridges, cuts, and fills.

DISCUSSION

Because the design specifications for DMA maps have changed periodically over the years, outdated maps[1] do not correspond to current map-design specifications. This means that students must be taught existing design specifications with emphasis on deviations they can expect to encounter when using outdated maps.

[1]Maps that have not been updated since the specifications were changed.

The design of DMA maps of areas within the United States is not the same as the design of DMA maps of foreign areas. This difference stems from the use of United States Geological Survey compilations in producing DMA maps of U.S. areas. Major differences are found in (1) the classification and portrayal of roads, railroads, and buildings, (2) the selection criteria (sizes) for copses and clearings, and (3) the classification criteria for vegetation. As a consequence, training on DMA maps of U.S. areas does not fully prepare students to use DMA maps of foreign areas.

The difference between DMA-prepared foreign maps and maps prepared by foreign cartographers is even greater than that between the DMA U.S. and foreign maps. Cross and Rogers (1980) discussed the lack of standardization among maps produced by the various countries of the world and pointed out numerous instances in which training on DMA maps would result in either zero training transfer or negative transfer to maps produced by foreign cartographers. Clearly, training on DMA maps does not fully prepare infantrymen to interpret the foreign-produced maps that may be distributed by DMA in the event of combat operations in foreign areas not yet mapped by DMA cartographers.

WORK IN PROGRESS

The experimental materials are currently being validated for task content and media compatibility using USMC subject matter experts (SMEs). They will be revised and organized per SME recommendations and tested for training effectiveness with participants from Marine infantry battalions.

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APPENDIX

TOPICS FOR TRAINING IN THE MECHANICS OF MAP AND COMPASS USE

TOPICS FOR TRAINING IN THE MECHANICS OF MAP AND COMPASS USE

I. INTRODUCTORY TOPICS

A. Historical background of maps/navigation.
B. Definition of map.
C. Need for navigation and map-interpretation skill.
D. Component skills required for land navigation.
   1. Personal skills.
      a. Maintaining awareness of surroundings.
      b. Knowledge of pace length.
      c. Good sense of direction.
   2. Map and compass skill.
      a. Accurately orient map.
      b. Select checkpoints on map and recognize on ground.
      c. Use compass to determine and follow azimuths (day/night).
      d. Determine ground distances from map and pace distances on ground.
      e. Locate position of self and distant objects on map.
E. Performance requirements.
   1. Navigate, by day, 3-kilometer course and locate 50-meter-wide objective. Complete course within 3 hours.
   2. Navigate, by night, 2-kilometer course and locate 50-meter-wide objective. Complete course within 2 hours.

II. DEFINITION OF MARGINAL INFORMATION

- Sheet name
- Sheet number
- Series name and scale
- Series number
- Edition number
- Map scale note
- Bar scales
- Credit note
- Index to adjoining sheets
- Index to boundaries diagram
- Projection note
- Grid note
- Grid reference box
- Vertical datum note
- Horizontal datum note
- Legend
- Declination
- Protractor scale
- User's note
- Unit imprint
- Contour interval note
- Coverage diagram (optional)
- Glossary (foreign maps)
- Classification (when classified)
- Special notes

III. DEFINITION OF TOPOGRAPHIC SYMBOLS

A. Legend.
B. Color code.

IV. INSTRUCTION ON HOW TO LOCATE POINTS ON A MAP

A. Geographic coordinates (concept of).
B. Polar coordinates (concept of).
C. Universal transverse mercator grid system (military grid reference system).
   1. UTM projection.

2. UTM grid zones.
3. 100,000-meter grid squares.
4. 10,000-meter grid squares.
5. 1,000-meter grid squares.
6. Grid lines.
7. Coordinates of grid lines.

D. Procedures for locating grid square (four-digit coordinates)

E. Procedures for locating points within grid square (six and eight-digit coordinates).
1. Use of "coordinate scale."
2. How to construct own coordinate scale using bar scale.
3. Six-digit coordinates.
4. Eight-digit coordinates.

V. INSTRUCTION ON SCALE

A. Definition of "map scale" and "representative fraction."

B. Relationship (general) between map scale, coverage, and detail.

C. Military classification of maps by scale.
1. Small scale (scale $\leq$ 1:600,000).
2. Medium scale (1:600,000 < scale < 1:75,000).
3. Large scale (scale $\geq$ 1:75,000).

D. Appropriate scale for various types of maps.
1. General maps (scale < 1:1,000,000)--general planning.
2. Strategic maps (scale = 1:1,000,000)--planning strategic operations.
3. Strategic tactical maps (scale = 1:250,000 or 1:500,000)--topographic maps used for tactical purposes by fast-moving units.
4. Road maps (scale = 1:250,000)--tactical and administrative troop movements.
5. Tactical maps (standard scale = 1:50,000, other = 1:25,000 & 1:100,000)--detailed planning and tactical operations by arms and services.
6. Artillery maps (scale = 1:25,000 or 1:50,000)--selecting gun positions and controlling unobserved fires.
7. Town maps (standard scale = 1:12,500).

VI. INSTRUCTION ON DISTANCE MEASUREMENT ON MAP

A. Use of metric system (centimeters/meters/kilometers).

B. Use of graphic scale.
1. Measuring straight line distances.
2. Measuring curves or irregular line distances.
3. Allowing for terrain characteristics (actual vs. horizontal distance).

C. Determining ground distance by using the representative fraction (RF).

D. Determining RF from map distance and ground distance ($RF = \frac{MD}{GD}$).

E. Determining RF from comparison.

VII. INSTRUCTION ON DETERMINING ACTUAL DISTANCE BY PACING

A. Determining average pace count.

B. Factors which affect pace count (most factors shorten).
1. Slopes.
2. Winds.

3. Surfaces.
4. Elements.
5. Clothing and equipment.
6. Stamina.

VIII. TIME, DISTANCE, RATE FORMULAS

A. Time ($T = \frac{D}{R}$).

B. Rate ($R = \frac{D}{T}$).

C. Distance ($D = RT$).

IX. ELEVATION AND RELIEF

A. Definition of terms.
1. Elevation--height of object above/below datum plane.
2. Datum plane--a reference from which elevation measurements are taken, usually average sea level.
3. Relief--the configuration of the ground.

B. Methods of showing elevation and relief.
1. Contours.
2. Hachures.
3. Layer tinting.
4. Shading.
5. Spot elevations (use as tactical names for unnamed hills).

C. Contour lines.
1. Contour interval.
2. Types of contours.
   a. Index.
   b. Intermediate.
   c. Supplemental.
   d. Depression.
3. Using contour lines to determine elevation (interpolating between lines).
4. Using contour lines to identify ground forms.
   a. Hills, peaks, ridges, and saddles.
   b. Slopes.
   c. Cliffs.
   d. Cuts and fills.
   e. Stream lines (gullies, ravines, draws, and stream junctions).
   f. Finger (spur).
5. Using contours to analyze terrain.
6. Using contour lines for profiling.
   a. Terms: topographic crest, military crest, intervisibility, mask, defilade.
   b. Procedures for drawing a profile.

X. DIRECTION AND AZIMUTH

A. Azimuth.
B. Units of azimuth measurement.
C. Back azimuth.

D. Base direction lines.
   1. True north.
   2. Magnetic north.
   3. Grid north.

E. Annual changes in magnetic north.
   1. Note on map that describes annual magnetic change.
   2. Procedure for allowing for annual magnetic change.

F. Determining map directions with protractor.
   1. Characteristics of protractor.
      a. Purpose.
      b. Index point.
      c. Base line.
      d. Scaled outer edge.
   2. Measuring grid azimuth.
   3. Plotting an azimuth.

G. Converting azimuths.
   1. Declination diagrams.
   2. Converting grid to magnetic.
   3. Converting magnetic to grid.

H. Determining ground directions with compass.
   1. The lensatic compass.
      a. Parts of compass (names of).
      b. Compass accuracy ($\pm$1-2^{o}).
      c. Factors affecting accuracy.
      d. Care and accuracy checks.
      e. Zeroing the compass.
   2. Determining azimuths.
      a. Holding position.
      b. Sighting/reading methods.

I. Determining azimuths on the map with a compass.
   1. Orient map using compass.
   2. Without disturbing map orientation, rotate compass body so straight edge aligned on line connecting points.
   3. Read value beneath index line.

XI. FOLLOWING A COMPASS AZIMUTH

A. Daytime.
   1. General Procedure.
      a. Set compass for desired azimuth.
      b. Assume center hold position.
      c. Rotate body until azimuth under index line.
      d. Select best steering mark directly ahead.
      e. Close compass and proceed to steering mark.
      f. Repeat above when arrive at steering mark or when steering mark lost from view.
   2. Selection and use of steering marks.
      a. Characteristics of good steering mark.
      b. Use of steering marks on back azimuth.
      c. Use of self-made back steering marks (stick, fire, pile of rocks, etc.).
   3. Detours.
      a. Small obstacles.
      b. Large obstacles (simple/complex detours).
   4. The offset.

B. Nighttime.
   1. Selecting steering marks.
   2. Setting compass for night use.
      a. Determine clicks to desired azimuth.
      b. Rotate bezel ring until luminous line is on index line.
      c. Rotate bezel ring desired number of clicks.
   3. Following azimuth without steering marks.
   4. Detours at night.

C. Factors affecting accuracy.
   1. Human tendency to veer.
   2. Improper balance of pack, rifle, etc.
   3. Elements.
   4. Terrain.
   5. Natural preference for right.

XII. ORIENTING THE MAP

A. Map orientation by inspection.

B. Map orientation by using compass.
   1. Compass--comparison method.
   2. Magnetic north--line method.
      a. Determine GM angle.
      b. Correct for annual magnetic change.
      c. Make tic mark on map protractor scale.
      d. Draw line between tic mark and protractor pivot point (P).
      e. Align compass straight edge with magnetic north line.
      f. Rotate map/compass until north arrow is under index line.

XIII. DETERMINING LOCATIONS

A. Methods of locating self.
   1. Inspection.
   2. Estimating distance.
   3. Resection.
      a. One-point resection (when located on/near linear feature).
      b. Two-point resection (two known/distant point features--with/without protractor).
   4. Using outside help.
      a. Infantry units.
      b. Artillery units.
      c. Aviation units.

B. Methods of locating distant objects.
   1. Inspection and estimation.
   2. One-point intersection.
      a. Compass only.
      b. Compass and protractor.
   3. Two-point intersection.

XIV. PLANNING AND PREPARATION

A. General considerations.
   1. Tactical situation.
   2. Mission.
   3. Time available for planning.

B. Liaison.
   1. Receipt of orders.
   2. Locate/interview others who are familiar with topography.

C. Reconnaissance.
   1. Purposes.
      a. Locate enemy positions.
      b. Comprehend lay-of-the-land.
      c. Update map.
      d. Identify type/location of features not depicted on map.
      e. Identify obstacles and undesirable terrain/vegetation/hydrography.
      f. Select/verify checkpoints.
   2. Types of reconnaissance.
      a. Air.
      b. Ground.
      c. Map.
      d. Photo.

D. Selecting the route.
   1. Locate/plot starting point and objective.
   2. Locate/plot the known/suspected locations of enemy positions.
   3. Locate/plot the known/suspected locations of obstacles.
   4. Evaluate terrain and map information between starting point and objective.
   5. Identify and evaluate potential routes.
      a. Tactical considerations.
      b. Terrain considerations.
   6. Select optimal general route.

E. Selecting checkpoints and plotting route.
   1. Types of checkpoints.
      a. Line.
      b. Point.
   2. Advantages/disadvantages of line/point checkpoints.
   3. Checkpoint selection.
      a. Distance between checkpoints (about 700 meters).
   4. Plotting the route.
   5. Identifying/plotting visible reference lines/points.

F. Final preparations.
   1. Determine magnetic azimuth and distance of each leg.
   2. Memorize route.
   3. Coordinate with friendly troops.
   4. Identify/obtain equipment.

XV. EXECUTION OF LAND NAVIGATION

A. Initial considerations.
   1. Confirm exact starting point (particularly for heliborne operations).
   2. Review mapped features along first leg.
   3. Set compass.
   4. Select steering marks or follow compass bearing.
   5. Proceed to location of first steering mark and select another steering mark.
   6. Count paces to first checkpoint.
   7. Repeat above at first checkpoint.

B. Considerations during march.
   1. Staying on course.
   2. Action if disoriented.
   3. Action at unexpected obstacles.
   4. Creation of mental map.
   5. Recording of important features.
   6. Action at checkpoints.

C. The navigational team.
   1. Unit leader.
   2. Navigator.
   3. Pacers.

D. Considerations for navigating at night.
   1. Daytime reconnaissance.
   2. Selecting checkpoints/routes suitable for night operations.
   3. Information sheet or luminous plotting board for night navigation.
   4. Use of luminous markings on personnel.
   5. Control and maintaining contact.
   6. Procedures for marines who lose contact.
   7. Use of senses other than sight.

XVI. MILITARY SYMBOLS AND OVERLAYS

A. Military symbols.
   1. Troop unit symbols.
   2. Meaning of colored symbols.
   3. Weapon and vehicle symbols.
   4. Entanglements.
   5. Obstacles, general.
   6. Obstacles, tank.
   7. Fighting holes and trenches.
   8. Boundaries and delimited areas.

B. Sketches and overlays.
   1. Panoramic sketch.
   2. Topographic sketch.
   3. Overlays.
      a. Reconnaissance overlay.
      b. Operation overlay.

XVII. AERIAL PHOTOGRAPHS

A. Uses.
B. Advantages/disadvantages over a map.
C. Types.
   1. Vertical.
   2. Low oblique.
   3. High oblique.
D. Types of film.
E. Marginal information.
F. Identification of terrain features.
   1. Size.
   2. Shape.
   3. Shadow.
   4. Tone.

G. Using aerial photographs as map substitutes.
   1. Determining scale.
      a. By using focal length and altitude.
      b. By comparison with a ground distance.
      c. By comparison with a map of known scale.
      d. By the dimensions of an identifiable object.
   2. Direction.
      a. Finding north by shadows.
      b. Locating magnetic north on a photograph from a map.
   3. Orientation.
   4. Point designation.
      a. Construction of a point designation grid.
      b. Use of a point designation grid.
H. Mosaics.
I. Photomaps.
J. Pictomaps.

XVIII. LAND NAVIGATION BY NATURAL MEANS

A. Planning.
B. Determining directions by nature's signs.
   1. Accuracy of natural methods.
   2. The North Star.
   3. The Southern Cross.
   4. Overhead star method.
   5. Shortest shadow method.
   6. Equal shadow method.
   7. Shadow-tip method.
C. Shadow clock.
D. Executing navigation by natural means.
   1. Staying on course.
      a. Steering marks.
      b. Cairns.
      c. Trailblazing.
      d. Indian file.
      e. Fires.
E. Actions during movement.
F. Actions at obstacles.
G. Actions if become disoriented.

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